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THE COOL-WATER TIMMS POINT PLEISTOCENE HORIZON AT SAN PEDRO, CALIFORNIA

BY

ALEX CLARK

California Institute of Technology

SAN DIEGO, CALIFORNIA

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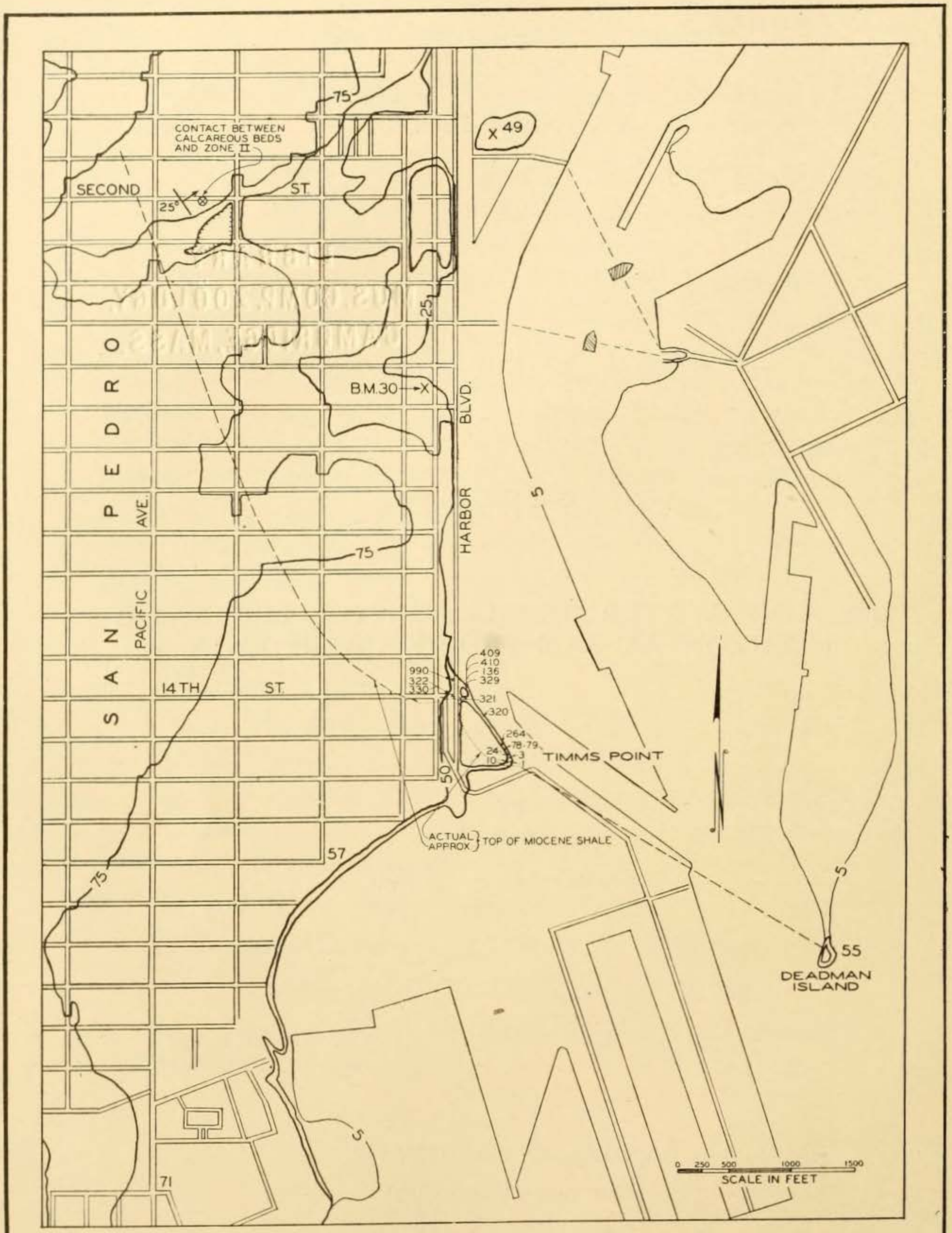

Sketch map of the town of San Pedro, California, indicating collecting localities at Timms Point.
(*Adapted from U. S. Geol. Survey, Wilmington Quadrangle*)

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INTRODUCTION

Timms Point is located in the southeastern part of the town of San Pedro, Los Angeles County, California, just east of the south end of Harbor Boulevard, along the bluff facing the harbor. It is part of the abandoned sea cliff extending from a locality near Point Fermin northward along the east side of the town. The cliff is about forty feet high and its top represents the lowest of a number of marine terraces cut in the Palos Verdes Hills.

Since Arnold[1] studied the stratigraphy and faunas of San Pedro no account of the section exposed at Timms Point has been published. As at that time the exposures there were poor, only 28 species of mollusks were collected and no detailed observations could be made with reference to the stratigraphy. It, therefore, seems desirable to record the results of an examination of the stratigraphy and fossils.

A fauna of 155 species of mollusks, bryozoa, and brachiopods has now been collected and studied from the so-called Pliocene beds exposed at Timms Point. Foraminifera and ostracods, the former in great abundance, were collected, but not studied. A close scrutiny of the physical evidence and the fossils seems to indicate the presence of two minor faunal zones.

ACKNOWLEDGMENTS

I wish to express my appreciation to Dr. W. P. Woodring, formerly Professor of Invertebrate Paleontology at the California Institute of Technology, for suggesting the problem and for advice and criticism. Mr. A. M. Strong kindly identified *Diala marmorea* and *Barleeia haliotiphila*. Mr. George Willett, of the Los Angeles Museum, permitted

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[1] ARNOLD, DELOS & RALPH, "The Marine Pliocene and Pleistocene Stratigraphy of the Coast of Southern California." Jour. Geol., Vol. X, 1902, No. 2.

ARNOLD, RALPH, "The Paleontology and Stratigraphy of the Marine Pliocene and Pleistocene of San Pedro, California." Mem. Calif. Acad. Sci., Vol. III, 1903.

comparison of some of the fossils with his Recent collection and offered suggestions as to their correct identification. Dr. U. S. Grant, IV, of the University of California at Los Angeles, criticized the faunal list. The Golisch collection of Recent shells, now at the California Institute of Technology was found indispensable in making comparisons with the fossils.

STRATIGRAPHY

The oldest rocks exposed at Timms Point consist of somewhat sandy, brown, fractured siltstone, intercalated with a few thin layers of hard yellow-weathering limestone, dipping northeastward at a somewhat steeper angle than the overlying beds. They are exposed on the west and south sides and in several places along the base of the east face of the bluff. The base of this formation is not exposed here, consequently the thickness is not known. Arnold referred these strata to the Miocene, without, however, any fossil evidence.

The beds to be described in detail are uncemented clayey fine sands and silts, predominantly yellowish with local finer gray streaks and patches. They lie unconformably on the irregular eroded surface of the Miocene shales. These beds strike N. 37° W. and dip northeastward at an angle of about 14°. The component of dip along the east face of the bluff is 8° where a thickness of about 30 feet is exposed. These beds, as well as similarly situated beds at Deadman Island, were considered of Pliocene age by Arnold.

About 200 yards north of the southeast corner of the bluff a concrete retaining wall several hundred feet long effectually hides the contact between the "Pliocene" and overlying beds. Unfossiliferous sands that are almost horizontal are found just north of the retaining wall. Farther north these sands are cross-bedded. The top of the section of tilted beds is at Second Street and Harbor Boulevard, where they consist of fossiliferous gray sands correlated by Arnold with the type Lower San Pedro of Deadman Island. It should be mentioned in this connection that Arnold[2] in his first paper designated Deadman Island as the type locality of the San Pedro series.

The horizontal Upper San Pedro beds truncate the whole section. At Timms Point, however, they are represented only by a very thin layer of Miocene shale and limestone cobbles exposed at the base of the soil

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[2] ARNOLD, DELOS & RALPH, op. cit. 1902.

mantle on the west side of the bluff along Harbor Boulevard. The upper five or six feet of the cliff is made up of soil and alluvium containing a few kitchen-midden shells.

The best exposure of the "Pliocene" beds can be seen on the east face of the bluff just south of the concrete retaining wall. At this locality the section is as follows, beginning at the top:

Bed No.		*Thickness*
III.	Yellowish-gray massive dirty fine sands, slightly coarser than underlying sands. Contains a few scattered specimens of *Lucina annulata* and locally a lens of about 6 inches thick packed with greatly leached fossils	16′
II.	Yellowish to greenish brown fine silty sand, containing scattered well-rounded pebbles of hard shale and limestone. Overlaps onto "Miocene" shale southward. Lamellibranchs abundant, gastropods and foraminifera not so abundant. Decidedly cool-water fauna	1′-2′
I.	Yellowish massive clayey silts with finer gray streaks and pockets. Somewhat marly in places near base. Numerous bored pebbles of the underlying shale and a few phosphatized pebbles are found at the base. Basal portion consists almost entirely of foraminiferal remains with some small mollusks. Toward middle of bed, mollusks, particularly gastropods, become more abundant. Bryozoa abundant locally toward south end of point. Fauna indicates somewhat warmer facies	12′
	Total	30′

Prior to the removal of several feet of material from the bluff at the southeast corner of Timms Point, the overlap of Bed No. 2 could be observed, where it rested directly on the Miocene shale. The same relation can still be seen on the west side of the bluff. This overlap may be due to an irregular surface of deposition and probably has little time significance, but it is interesting to notice that the faunas of Bed No. I and Bed No. II are considerably different, as will be indicated below.

FAUNA

Arnold listed the following 28 species from Timms Point:

LAMELLIBRANCHIATA

Callista subdiaphana
Leda taphria
Lucina acutilineata
Nucula castrensis
Pecten caurinus
Pecten jordani
Protocardia centifilosa
Solen sicarius
Thyasira bisecta
Thracia trapezoides
Thyasira gouldii
Venericardia barbarensis
Venericardia ventricosa

GASTROPODA

Bittium asperum	Drillia torosa	Natica clausa
Chrysodomus tabulatus	Fusus barbarensis	Olivella biplicata
Columbella gausapata	Nassa mendica	Terebra simplex
Columbella var. carinata	Nassa cooperi	Trophon stuarti
Conus californicus	Nassa perpinguis	Turritella cooperi

Mitrella carinata and *Terebra "simplex"* were not found during this study. In his paper on the California Pectens, Arnold[3] listed *Chlamys hastatus navarchus* (Dall) from Timms Point. *"Tritonofusus" riversi* Martin was described by Martin[4] from the same locality. Neither of these species was encountered.

In the accompanying faunal list from the Timms Point beds, the specific nomenclature and, for the most part, the generic nomenclature follows that of Dall.[5] The present range of species is also taken from Dall's paper. The letter R indicates that a species is represented at a locality by three or less specimens. The letter C denotes *common* (3 to 20 specimens). The letter A indicates that 20 or more specimens were found at a locality. In the column marked "Living," species now found only north of Point Conception are indicated by the letter N. Species ranging only south of that locality are designated by the letter S. Species which range both north and south of Point Conception are indicated by an X. Species which are believed to be extinct are designated with the letter E.

The column marked "Calcareous Beds" includes the species common to Timms Point and the faunas as recorded by Woodring[6] from the calcareous beds and marls exposed at Second Street and at Hilltop Quarry. The species in the column marked "Timms Point Formation at Second Street" are those found also by Woodring in the silts above the calcareous beds. In the remaining three columns, Arnold's lists were consulted, augmented in the case of the "Lower San Pedro" column by species listed by Oldroyd.[7] Canu and Bassler's[8] list of bryozoa from the Deadman

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3 ARNOLD, RALPH, "The Tertiary and Quaternary Pectens of California." U. S. Geol. Survey, Prof. Paper No. 47. 1906

4 MARTIN, BRUCE, "Descriptions of New Species of Fossil Mollusca from the Later Marine Neocene of California." U. of Cal. Pub. in Geol., Vol. 8, No. 7. 1914.

5 DALL, W. H., Bulletin 112, U. S. Nat. Mus. 1921.

6 WOODRING, W. P., "Warm-Water Faunas of the So-Called Pliocene of San Pedro" (abstract). Bull. Geol. Soc. Am., Vol. 41, No. 1. 1930.

7 OLDROYD, T. S., "The Fossils of the Lower San Pedro Fauna of the Nob Hill Cut, San Pedro, California." Proc. U. S. Nat. Mus., Vol. 65, Art. 22, 1924.

8 CANU, F. and BASSLER, R. S., "Later Tertiary and Quaternary Bryozoa of North America." Bull. 125, U. S. Nat. Mus. 1923.

CHECK LIST OF FOSSILS FROM THE TIMMS POINT FORMATION AT TIMMS POINT

	ZONE I							ZONE II														
	Bed No. 1							*Bed No. II*						*No. III*		*Pleistocene Unconformity*		*Calcareous Beds*	*Coarse, Ex. Fos. at Vertical Str.*	*Diadophora (= Plicatula)*	*L. Lee Pebbles*	*U. Lee Pebbles*	
GASTROPODA	264	329	1	78	176	320	350	10	24	77	321	322	410	409	960	1	274						*Living*
Acmaea insessa (Hinds)			x						x			x		x				x		x	x	x	x
Diodora aspera (Eschscholtz)					x																x	x	x
Puncturella galeata (Gould)	C	x	x		x							x		x				x		x	x	x	x
Puncturella cucullata (Gould)	x		x		x	x	x					x									x	x	x
Tegula montereyi (Kiener)	x		x					x		x		x				x	x	x	x	x	x	x	x
Callomitrna annulatum (Martyn)			C											x	x						x	x	x
Callomitrna variabilis(atum (Martyn)			x		x					x		x		x				x	x	x	x	x	x
Callomitrna constatum (Martyn)								x										x					x
*Callomitrna sp.		x																x					
Cidarina cidaris (A. Adams)	x				x		x			x		x								x			x
Solariella peramabilis Carpenter	x		x	x		x		x		x		x							x	x			x
Turcica caffea Gabb			C	x												C	x			x			x
Margarites ophalius (Carpenter)			x														x				x		x
Margarites pupillus (Gould)												x											x
Astraea inaequalis (Martyn)	x		x	C	C	x	x		x							x					x	x	x
Homalopoma luridum (Carpenter)		C																			x	x	x
Homalopoma carpenteri (Pilsbry)				x				x								x					x	x	x
Tricolia pullioides (Carpenter)		C																					x
*Turbonilla cf. pedroana Dall and Bartsch			x																				x
Epitonium indianorum (Carpenter)			x		x		x				x	x							x	x	x	x	x
Turritomatica clausa (Broderip and Sowerby)			C		x	x	x	C	x			x					x	x	x	x	x	x	x
Eulima lewisi (Gould)					C	x		x		x								x					x
Niotaria reclusiana (Deshayes)	x							x		x		x						x	x	x	x	x	x
Crepidula princeps Conrad	x				x																		x
Crepidula adunca Sowerby					x													x			x	x	x
Crepidula lingulata Gould	x		C		C	x	x					x				x		x			x	x	x
Crepidula nummaria Gould					x		x			x								x			x	x	x
Calyptraea mamillaris Broderip							x														x	x	x
Bittium dalli Bartsch		x																x			x		N
Barleeia haliotiphila (Carpenter)		C																x					S
"Diala" normalis Carpenter		C																x					S
Spiroglyphus linatilus (Mörch)																	B	x					S
Turritella cooperi Carpenter			A		C	B	C	C	B		B	C		B		A	A	x	x	x	x	x	S
Turritella jewetti Carpenter			B	B	C	C	x	C	B	B		x				B	B	x		x	x	x	S
Cerithiopsis necropolitana Bartsch			B																		x		E
Bittium asperum (Gabb)	C	C																x		x	x	x	S
Bittium annulatum boreale Bartsch			B				x																N
Bittium catalinense Bartsch	B																	x			x		S
Bittium giganteum Bartsch				B				C	C	C								x	x		?		E
Bittium lacus Bartsch	B		B																				S
Bittium ornatissimum Bartsch	B		C		C		C					k?						x			x		B
Bittium rugatum Carpenter								x	B			x						x	x		x	x	S
*Bittium cf. rugatum Carpenter			C		C	C	C	x				x					C	x					S
Bittium serra Bartsch							x																
*Bittium sp. indet.															C								
Alaba californica (Dall and Bartsch)		x																x			x		E
Fusinus oregonensis (Redfield)			x		x	x	x	x	x			x				x	x	x		x	x	x	x
Tritonalia barbarensis (Gabb)					x	x												x			x		x
Boreotrophon multicostatus (Eschscholtz)					C	x															x		x
Boreotrophon orpheus praecursor (Arnold)	x	x	C		C	x	x		x									x			x		E
Boreotrophon pacificus (Dall)	x																				x		x
Boreotrophon stuarti (E. A. Smith)					x													x	x		x		x
Mitrella gausapata (Gould)	x		x	x	C			C	x			C						x	x	x	x	x	x
Mitrella tuberosa (Carpenter)		C																x			x	x	x
Amphissa reticulata Dall	x	x	C		C	x												x	x				x
Nassarius cooperi (Forbes)	x		C		C													x	x	x	x	x	x
Nassarius mendicus (Gould)			x		C	x						x						x	x	x	x	x	x
Nassarius perpinguis (Hinds)			x		C	x		x										x	x	x	x	x	x
Cantharus fortis (Carpenter)					x													x					E
Nepteunea tabulata (Baird)			x		C	x		x		x		x		C	x			x	x	x	x		x
*Neptunea ? sp.								x															
"Exilia" rectirostris (Carpenter)			x		C				x	x		x				x	x						
Barbarofusus barbarensis (Trask)	x		x	x	A	C	x	x				x				x	C	x	x	x	x	x	x
Barbarofusus kobelti (Dall)					x																		x
Metis ulax Melvill												x					x	x			x	x	x
Cypraeolina pyriformis (Carpenter)		x																x					
Olivella biplicata Sowerby	C		C	x	x	C	x			x		x			x		C	x	x	x	x	x	x
Olivella pedroana (Conrad)	x					x		x				x						x			x	x	x
Adnete southoni gracilior (Carpenter)																	x	x					x
Conus californicus Hinds					x	x		x										x	x		x	x	x
Amphissa perversa (Gabb)	x		x		C	x	x	x	x		x	C					x	x			x	x	x
Amphissa totula Dall			x			C						C									x	x	x
Amphissa santarosana Dall									x	x											x	x	A
Clathurella crystallina (Gabb)					x	x												x					S
Boreosella barbarensis Dall			x			x															x	x	x
Borsonella bartschi (Arnold)	x		C		C	C	x										x	x			x	x	S
"Clathrodrillia" remondi (Arnold)					x																x	x	A
Pseudomalaxis merriami (Arnold)			x																		x	x	A
Pseudomalaxis moesta (Carpenter)			x															x					x
"Taranis" arcuigi (Arnold)			x						x									x			x		x
**"Clathurella" sp.					x																		
"Lora" viridula (O. Fabricius)			x		x													x			x	x	N
"Lora" tabulata (Carpenter)			x		x													x					N
"Mangilia" oldroydi (Arnold)			x		x													x			x		E
Actaeina culcitella (Gould)			C			x	x											x	x		x	x	N
Actaeina harpa (Dall)			x		x	x												x		x	x	x	x
SCAPHOPODA																							
Cadulus fusiformis Pilsbry & Sharp	x		x															x	x		x		x
Dentalium neohexagonum Sharp & Pilsbry			x		x													x		x	x	x	x
LAMELLIBRANCHIATA																							
Acila castrensis (Hinds)			C	x	C		C	x	x		x	C				C	C	x	x	x	x		x
Nuculana minuta praecursor (Arnold)	C		C				x										B	x	x	x	x		E
Nuculana taphria (Dall)			x					C	x	x	C	C						x	x	x	x	x	x
Yoldia scissurata Dall			x		x					x		x				x		x			x		x
Pecten diegensis stearnsi Dall			x			C	x	x			x					x		x					E
"Pecten" caurinus Gould			x	x	x	x		C	x	x	x	C		x	x	C	x		x	x	x	x	N
Chlamys hastatus hastatus (Sowerby)			C		x	x	C			x	x	x		x		C	C	x	x	x	x	x	x
Chlamys islandicus hindsi (Carpenter)					x													x		x			x
Chlamys jordani (Arnold)	x		x	x	C	x	C	C	C	C	x	C		C		x	C		x	x	x	x	x
Hinnites giganteus (Gray)													x								x	x	x
Monia macroschisma (Deshayes)			x		C	x	x	x	x	x						x		x			x	x	x
Volsella hamicata (Carpenter)			x	x						x		x				x			x		x	x	x
Crenella columbiana Dall						x												x			x		x
Thracia trapezoides Conrad			x	x	x	x	x	x				x			x	C			x	x			N
*Cyathodonta cf. pedroana Dall								x													x		S
Pandora filosa (Carpenter)						x				x											x		x
Pandora grandis Dall										c		c				x			x				N
Poromya tenuicincta Dall	x				x													x					x
Cuspidaria pectinata (Carpenter)			x															x			x		x
Verticordia ornata (D'Orbigny)			x															x			x		S
Cardita barbarensis (Stearns)			x		x		x													x	x	x	S
Cardita ventricosa Gould	x		C	x	A		C	A	C	C	x	A		C	C	C	A	x	x	x	x	x	x
Pseudochama exogyra (Conrad)			C		x		x					x					x	x				x	x
Thyasira disjuncta (Gabb)												C			A					x			N
Thyasira gouldii (Philippi)			x					x	C	C		C		C				x	x	x	x	x	x
Axinopsis viridis Dall																	x	x	x				x
Diplodonta orbella (Gould)																x		x					x
Lucina annulata Reeve	x		x	x	x		x	A	C	x	C	C		A	C	x	C	x	x	x	x	x	x
Lucina californica Conrad			x				x			x		x				x		x		x	x	x	x
Lucina nuttalli Conrad							x					x							x		x	x	S
Lucina tenuisculpta Carpenter						C											x	x			x	x	S
Trachycardium quadragenarium (Conrad)					x							x				C		x					S
Cerastoderma corbis (Martyn)					x			x	x	C		x				x	x	x	x		x	x	S
"Protocardia" centrifossa (Carpenter)	x		C		C		x	x		x	x	C				C	C	x		x	x	x	x
Sanguinolus nuttallii (Conrad)					x											x		x		x	x	x	x
Venus pedroanensis (Conrad)								x		x	x							x					E
Venerella subdiaphana (Carpenter)				C	x			x	x	C	x	x		x	C	C	x	C	x	x			x
Psephidia ovalis Dall		x	C		x	C											C	x	x				x
Psephidia ornata Dall																	C	x	x				S
Tellina buttoni Dall																	x	x			x	x	S
Macoma inquinata (Deshayes)							x													x	x	x	N
Macoma calcarea Gmelin (small var.)			C	x	C			A	C	C	x	C		x	A	C	C	x	x	x	x	x	N
Semele incongrua Carpenter					x	x										x		x	x		x		N
Semele rubropicta Dall											x					x					x		x
Solen sicarius Gould			x	x	x					x		x				C		x	x	x	x	x	x
Schizothaerus nuttallii (Conrad)			x																			x	x
Mya truncata (Linné)										x													x
Panopea generosa Gould				x	C			x			x					x		x	x	x	x	x	x
Panomya ampla Dall					x			x				x				C			x	x	x		N
BRACHIOPODA																							
Laqueus californicus vancouverensis Davidson							x			x							x			x			N
Dallinella cf. hemphilli (Dall)				x						x									x				E
BRYOZA																							
Callaria mandibulata Hincks	x		x					x									x						S
Conopeum barbarense (Gabb & Horn)			x																				E
Entalophora fasciculifera Canu & Bassler																	C			x			E
Filisparsa clarki Canu & Bassler			C														C						E
Idmonea californica D'Orbigny	x		A				x										A			x			E
Lagenipora spinulosa Hincks			x														x			x			E
*Lichenopora cf. californica Conrad			x														x						E
Membranipora tuberculata (Bosc)			x																				x
*Microporella cf. ciliata Linné			x														x			x			x
Microporella eustimata Gabb & Horn			x														x						E
Rhabdopora labiata Gabb & Horn			x																	x			E
Smittina discoidea Canu & Bassler			x																				E
Tubucellaria punctulata (Gabb & Horn)			C				A										A			x			E
CRUSTACEA																							
Balanus sp.								x															
Cancer sp.			x																				
FISCES																							
Gobius zygonus? Jordan & Gilbert												x											x

*Species not included in computing percentage of extinct species.

Island "Pliocene" was also used in determining the geologic range of these forms.

Following is a list of California Institute of Technology collecting localities at Timms Point:

264.—200 feet north of southeast corner of Timms Point and on the east face. Basal 2 feet of Bed No. I resting directly on Miocene shale. Foraminifera extremely abundant.

329.—North end of east face of bluff just south of concrete retaining wall. Base of section same as at 264 but a hard limey layer containing broken fossils intervenes between the abundant forams and the contact with the Miocene. No species were identified from the limey layer.

3.—East face of bluff 50 feet north of southeast extremity. Bed No. I. Bryozoa extremely abundant.

78.—East face of bluff 150 feet north of southeast extremity. Bed No. I. Fossils came from 4 feet below Bed No. II, which is highest fossil bed exposed at this locality.

136.—Same locality as 329 but in middle and upper portion of Bed No. I.

320.—East face of bluff 450 feet north of southeast extremity and just south of small red shack. Middle and upper portions of Bed No. I.

330.—Low bank along sidewalk on west side of Harbor Boulevard at the end of Fourteenth Street. Bed No. I. Bryozoa abundant.

10.—Near top of bluff at, and just north of, southeast extremity. Uppermost fossil bed rests on Miocene shale here. This is Bed No. II.

24.—Same locality and bed as 10, but 30 to 40 feet north. Here several feet of Bed No. I intervene between Bed No. II and the Miocene contact.

77.—Same locality as 78, but 4 feet stratigraphically higher in Bed No. II.

321.—East side of Harbor Boulevard opposite end of Fourteenth Street. Bed No. II resting directly on Miocene,

322.—Same locality as 330, but about 4 feet stratigraphically higher and on gentle slope above the bank. Bed No. II.

410.—Same locality as 329, but about 12 feet stratigraphically higher, in Bed No. II. There are abundant fossils at this locality, but only one was collected because the bed can be definitely traced southward to a more accessible collecting locality.

409.—Same locality as 329, but about 14 feet stratigraphically above, in thin fossil lense near base of Bed No. III.

990.—150 feet north of 330 on west side of Harbor Boulevard on slope about 10 feet above sidewalk. 30 feet stratigraphically above Bed No. II. *Thyasira disjuncta* abundant here.

1.—Southeast corner of bluff at base of exposed section. Stratigraphic position uncertain due to slumping.

274.—Timms Point along the east face. Collected by students from various localities along the east face of the bluff.

FAUNAL SUMMARY

	Bed No. I	*Bed No. II*	*Bed No. III*	*Total*
Gastropods	78	38	5	86
Lamellibranchs	38	32	10	49
Scaphopods	2	0	0	2
Brachiopods	2	2	0	2
Bryozoa	13	2	0	13
Crustacea	1	1	0	2
Pisces	0	1	0	1
TOTAL	134	75	15	155
Specifically identifiable mollusks	114	66	14	130
Extinct mollusks	10	5	.....	11
Percentage of extinct mollusks	8.8	7.6	.....	8.5
Percentage of extinct bryozoa	.....	.....	.....	72.7

Bed No. I contains 69 species not found in the beds above. Bed No. II contains 13 species not found in Bed No. I. All the species recognized in Bed No. III are present in Bed No. II.

Several species are present in Bed No. II that are not found living south of Oregon today and some of these have Puget Sound as their southern limit. The species are as follows: *Pandora grandis, Thyasira disjuncta, Mya truncata, "Pecten" caurinus, Chlamys jordani, Thracia trapezoides,* and *Panomya ampla.* The first three of these species were not found in Bed No. I.

Several fossils occur at locality 990, 30 feet above Bed No. II and evidently in Bed No. III. The presence among them of *Thyasira disjuncta, Thracia trapezoides,* and *Pecten caurinus* indicates that this bed also represents the typical cool water zone present in Bed No. II.

Bed No. I carries a number of species whose present range does not extend north of Point Conception. On the other hand most of these species range south along the coast of Lower California, thus indicating warm-water rather than cool-water affinities. Species living only south of Point Conception can certainly be considered to belong to a warmer-water fauna than those found living only north of Siletz Bay, Oregon. The species not found north of Point Conception are as follows: *Turcica*

caffea, Tricolia pulloides, Rissoina dalli, Bittium larum, Bittium catalinense, Borsonella bartschi, Clathrodrillia renaudi, Verticordia ornata, Lucina nuttallii, Psephidia cymata, Turritella jewetti, Cardium quadragenarium, and *Cellaria mandibulata.* All but the last three of these species were found only in Bed No. I.

Several relatively warm-water species occur in Bed No. II, but they are rare as compared to their occurrence in the bed below. The simplest explanation of their presence in a cool-water fauna is that they have been derived from the lower bed by reworking. Little concrete evidence is available to support such an explanation except that the specimens of *Turritella jewetti* appear to be considerably worn and the *Cardium quadragenarium* is represented only by worn fragments. The fact that shells are worn or broken cannot be taken as conclusive proof that they are reworked from an older deposit, as it is quite common to find such specimens of Recent shells along the beach where wave action has worn and broken them.

The presence of this markedly cool-water fauna in Beds II and III cannot be entirely accounted for by assuming that it represents a deeper water deposit than the underlying warmer-water fauna. The somewhat coarser materials in Beds II and III, the presence of the overlap, and the character of the fauna indicate that this bed was laid down in shallower water than Bed No. I. The conclusion follows that the cooling of the water was due to a cooler climate, rather than to an increase in depth of the water. Such a marked change in climate was undoubtedly due to the advent of a glacial stage.

The occurrence of such cool-water species as *"Pecten" caurinus, Chlamys jordani,* and *Thracia trapezoides* in Bed No. I with a fauna that has a warmer aspect is not readily understood. A number of explanations may be considered:

1. Bed No. I and Bed No. II both represent cool-water facies and all the warm-water species are reworked from underlying beds not present at Timms Point, but occurring at Second Street in San Pedro about a mile away, as described by Woodring.

2. Bed No. I represents a warm-water horizon and the cool-water species have been reworked from a lower cool-water horizon not present here.

3. Bed No. I contains more than one zone of alternating cool and

warm-water facies, thus giving the appearance of a mixture of cool and warm-water species.

4. During deposition of Bed No. I the waters were becoming cooler and cool-water species began to appear before the warmer water types were driven out by the unfavorable environment. This postulates an interfingering of two faunas such as is observed at the border of two faunal provinces at the present time.

The principal objection to the first explanation is that a number of warm-water species are present in Bed No. I which do not occur in the underlying warm-water beds at Second Street. *Turcica caffea*, which is abundant in Bed No. I at Timms Point, but not found at Second Street or any other underlying warm-water beds exposed around San Pedro, is a notable example. There is a possibility that the warm-water forms in Bed No. I were derived from an unknown set of beds below that are now removed by erosion.

The second explanation offered has little support in the light of present knowledge of beds underlying the Timms Point section. No fauna occurring below the Timms Point beds is known in the vicinity of San Pedro that contains *"Pecten" caurinus* or *Thracia trapezoides*, two of the notably cool-water species occurring in Bed No. I. It is possible here also that such a zone has been removed by erosion or cannot be found due to lack of exposures.

No confirmation of the third explanation was obtained from the field evidence. No break in sedimentation or slightest indication of the presence of more than one bed in Bed No. I at Timms Point could be detected.

Arnold[9] used the fourth explanation in connection with the association of warm- and cool-water types in the Lower San Pedro sands. Later Oldroyd[10] employed the same reasoning in his discussion of the Lower San Pedro fauna at Nob Hill, San Pedro. Bed No. I contains a fauna indicative of several fathoms depth at the time of deposition. This may account for the early appearance of some of the cool-water forms that presumably were beginning to arrive from the north. The warmer-water forms had not yet retreated southward. Whether such a mingling of species of different environments can take place, is not at present proven.

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9 ARNOLD, RALPH, op. cit. 1903.

10 OLDROYD, T. S., op. cit. Page 2.

In view of the present limited knowledge regarding the "Pliocene" sections in and around San Pedro, it seems to be the most reasonable theory.

RELATION TO SECOND STREET SECTION

The section along Second Street has been referred to above. In order to bring out its relations to the beds at Timms Point, a brief description of the stratigraphy there seems warranted. Woodring[11] has described the section and studied the fossils. The base of the section is not seen in this vicinity due to lack of exposures. The Miocene shale outcrops in the first alley west of Pacific Avenue just south of Second Street. No exposures are available from this point eastward for at least a hundred yards. The first exposure of the "Pliocene" beds occurs on Second Street half a block east of Pacific Avenue. The lowest beds exposed in the section occur in a small quarry in the alley just south of the street. They consist of fossiliferous marly beds containing a relatively warm-water fauna. These beds are overlain by calcareous beds also carrying a warm-water fauna. The total thickness of marl and calcareous beds exposed is 68 feet. These faunas are warmer in facies than that in Bed No. I at Timms Point as indicated by the entire absence of *"Pecten" caurinus* and *Thracia trapezoides*. Disconformably overlying the calcareous beds are dirty silts and sands carrying the typical cool-water fauna corresponding to that in Beds II and III at Timms Point. These beds also have the lithologic characters of Beds II and III. Three fossiliferous beds occur on the south side of the street in this upper division separated by intervals of barren sand. Above these fossiliferous beds the deposits become thin-bedded and intercalated with thin beds of clean sand and the dip decreases from about 25° northeastward to less than 15°. These beds grade upward into the same cross-bedded sands as those seen north of the concrete retaining wall previously mentioned. Another break in the exposures occurs just west of Beacon Street and no more exposures are found until the Lower San Pedro fossiliferous sands are encountered at Second and Beacon Streets.

Besides the lithologic and faunal similarity of the cool-water horizons at the two localities, the field evidence supports the conclusion that they represent the same zone. The strike of Bed No. II at Timms Point is N. 37 W., whereas the strike of the contact between the Miocene shale and the overlying silts is about N. 45 W. This divergence in a north-

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11 WOODRING, W. P., op. cit. The thicknesses of the units in the Second Street section were kindly supplied by Dr. Woodring.

westerly direction permits the appearance of other beds below Bed No. II as the contact is followed in the direction of Second and Pacific Streets.

An examination of collections from the basal two feet of Bed No. I indicated a difference which was at first thought to represent a separate zone. Several species of small gastropods are found in considerable abundance, such as: *Homalopoma bacula, Tricolia pulloides, Rissoina dalli, Diala marmorea, Bittium asperum, Bittium catalinense, Alabina californica, Mitrella tuberosa,* and *Cypraeolina pyriformis.* These species occur in pockets and patches at or near the base, but were not seen farther up in the bed. Woodring has found these species to be quite common in the calcareous beds below the cool-water horizon at Second Street. At places along the bluff at Timms Point the base of Bed No. I carries virtually no sand or silt but consists of a concentrate of nearly pure foraminiferal remains. A small pebble of calcareous material containing several small species of gastropods common in the calcareous beds on Second Street, was found five feet above the base of Bed No. I at C. I. T. locality 320. No calcareous lenses or beds were observed in the silts at Timms Point, although the lower portion of Bed No. I is somewhat marly. All this evidence taken together indicates that the entire section at Timms Point lies above the calcareous beds on Second Street and that Bed No. I carries material reworked from the calcareous beds, that is, Bed No. I at Timms Point falls between the calcareous beds and the cool-water overlying sands on Second Street. It is possible that part of the calcareous beds grade laterally into the silts found in bed No. I at Timms Point. If this change actually does take place, then the fauna would necessarily change also, since there is a considerable difference in the faunas at the two localities. Such a possibility need not be seriously considered.

RELATION TO DEADMAN ISLAND SECTION

Unfortunately I did not have the opportunity to visit Deadman Island, before it was blasted away. Any attempt, therefore, to compare in detail the section there with that at Timms Point will not be entirely satisfactory. The faunas taken as a whole compare very closely, except that only 87 species were recorded by Arnold from the Deadman Island "Pliocene," though more species have very likely been added by the collecting of Crickmay[12] and his students.

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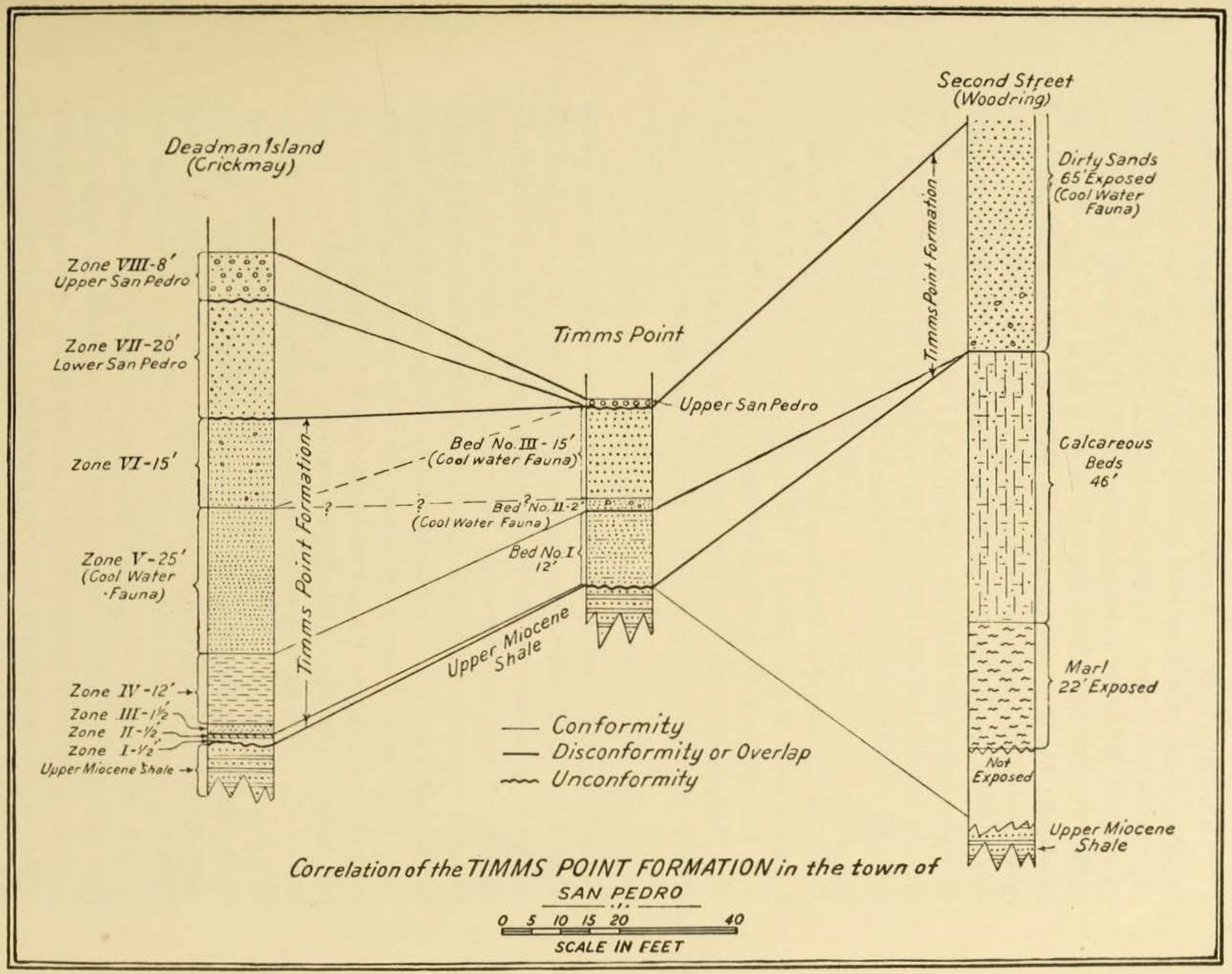
12 CRICKMAY, C. H., "The Anomalous Stratigraphy of Deadman's Island, California." Jour. Geol., Vol. XXXVII, 1929, No. 7.



Correlation of the TIMMS POINT FORMATION in the town of

Considered in detail, the sections differ somewhat. At Timms Point, the section can only be divided into three distinct beds representing two different faunal zones. On the other hand, Crickmay divides the Deadman Island "Pliocene" section into six zones. These zones do not appear sufficiently distinctive faunally to be of more than local importance. In most cases, the indicated temperature differences between the zones are minor and could readily be accounted for by local changes in current or depth. His Zones 1, 2, and 3 were not recognized at Timms Point. Since Crickmay found that Zone 3 overlaps Zones 1 and 2 on Deadman Island, they are very likely overlapped at Timms Point. His Zone 3 contains no distinctive fossils which are not present in Bed No. I at Timms Point, so is included with Zone 4 as the correlative of Bed No. I. Crickmay's Zone 4, characterized by abundant forams, bryozoa, and numerous small mollusks, is readily recognized at Timms Point as Bed No. I. His Zone 5 is, as he points out, "the only decidedly cool-water fauna" in this region. This fauna is represented at Timms Point by Beds II and III. His Zone 6 contains no unique forms by which it may be recognized at Timms Point.

AGE

It is difficult to accurately estimate the percentage of extinct species when some of the determinations are doubtful as is the case here. A number of the smaller mollusks cannot be satisfactorily identified without comparison with type material. Very likely some of the small forms present here, and not recorded as living, actually are to be found in the Recent fauna but under a different name. No attempt has been made here to deal with synonomic problems. Leaving out of consideration the more doubtful species (indicated in the faunal list by an asterisk), the percentage of extinct mollusks for the two zones at Timms Point is found to be 8.5%. This figure is much less than that given by Arnold for the "Pliocene" (17.3%). It is to be expected that a more detailed comparison of the fossil with the living specimens will reduce the figure. A more complete fauna, including a number of species known hitherto only in the Recent or San Pedro faunas, also tends to lower the percentage of extinct species. The species found at Timms Point which have not previously been reported as fossils are: *Axinopsis viridis, Barleeia haliotiphila, Bittium attenuatum boreale, Bittium larum, Bittium serra, Clathurella crystallina, Diala marmorea, Poromya tenuiconcha,* and *Tricolia pulloides.* Species found which have not previously been reported from below the Lower San Pedro are: *Alabina californica, Astraea inaequalis, Bittium*

giganteum, Bittium ornatissimum, Crepidula nummaria, Cuspidaria pectinata, Margarites optabilis, Pandora filosa, Rissoina dalli, Spiroglyphus lituellus, and *Verticordia ornata.*

The percentage of extinct species of bryozoa present in the Timms Point beds is 72.7%. This result is strangely at variance with the figure for the mollusks. The extremely large percentage of extinct species of bryozoa can hardly be due to the more rapid change in time of these organisms as compard to that of mollusks. The Recent bryozoa have not been studied or reported to the extent of the Recent mollusks. Consequently, it may be anticipated that many of the bryozoa recorded here as being extinct will be found living when more attention is paid to the Recent members of this group.

An age determination on the basis of extinct species is not entirely trustworthy, in that the concept of the limits of a species changes from time to time and varies with the individual paleontologist. Increasing data on Recent species changes the percentages also. It has usually been considered, however, that a fauna containing 10% or less of extinct species is Pleistocene in age.

If one considers the total fauna at Timms Point together with that of the underlying Second Street marls and calcareous beds, it will be found that it corresponds quite well to that of the Lower San Pedro as given by Arnold. Both percentage of extinct species and the percentage of species common to the two indicates the close relationship. Arnold placed the division between Pliocene and Pleistocene below the 12 feet of Lower San Pedro beds on Deadman Island and considered the 45 feet of sands underlying them as Pliocene. The reasons given for so doing were: (1) angular unconformity there between the two sets of beds; (2) Percentage of extinct species ("Pliocene" 17. 3% and Lower San Pedro 12.5%); (3) Faunal differences between the two.

There is no means of finding the relations between these two sets of beds on the mainland due to lack of exposures at critical points. Arnold, however, indicated that they are probably comformable at the place where the concrete retaining wall now stands just north of Timms Point. The marked faunal difference between the "Pliocene" and Lower San Pedro does not seem to have any time significance, but rather represents a facies difference due to difference in depth of water at the time of deposition and to difference in temperature. Warmer water zones below the typical cool-water zone at Timms Point compare more favorably in faunal content with the Lower San Pedro than with the immediately overlying fauna of

cool-water aspect. Faunal and stratigraphic breaks are present within the "Pliocene" section in the vicinity of San Pedro which may well be as great as that between the "Pliocene" and Lower San Pedro on Deadman Island. The conclusion drawn from such reasoning is that the "Pliocene" beds are part of the same series as the Lower San Pedro horizon and are little older, that is, they are early Pleistocene in age. Tieje[13] was the first writer to intimate that the "Pliocene" cool-water horizon belongs in the Pleistocene since Arnold placed it in the Pliocene.

Correlations by means of comparisons of faunal lists only, are usually found to be misleading. The most satisfactory method is to directly compare the material from the sections involved. For this reason no attempt will be made to correlate in detail the section described here with other localities of approximately the same age. It is clear, however, that the name Santa Barbara formation cannot be applied to the Timms Point beds, due to the presence of several extinct species in the lower portion of Santa Barbara section at Santa Barbara and their absence in the Timms Point beds. Notable among these is *Pecten bellus* Conrad. It is believed that at least the lower part of the Santa Barbara section is older than the Timms Point beds. The name San Diego formation is likewise inappropriate. The percentage of extinct species in the San Diego Pliocene is between 30% and 40% or thereabouts, which is in sharp contrast to the 8.5% extinction for Timms Point. The presence of a number of extinct species in considerable abundance at San Diego and unknown in the "Pliocene" in the vicinity of San Pedro, together with the absence in the San Diego Pliocene of the characteristic cool-water species of the Timms Point beds, is further evidence that the San Diego formation is older than the Timms Point beds.

In view of the lack of a convenient term for this horizon, which has variously been called Santa Barbara, San Diego, and Deadman Island Pliocene, the name Timms Point is proposed for the silts and sands overlying the Miocene shale and underlying the Lower San Pedro sands, with the section described at Timms Point as the typical section. Whether these beds carrying a cool-water fauna are to be considered a formation or not is largely a matter of personal opinion. Certainly in the vicinity of San Pedro these beds are lithologically distinct from the underlying calcareous beds and from the overlying Lower San Pedro sands.

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13 TIEJE, A. J., "The Pliocene and Pleistocene History of the Baldwin Hills, Los Angeles, California. A. A. P. G. Bull., Vol. 10, No. 5, p. 506. 1926.

CONCLUSIONS

The essential conclusions arrived at in this study are:

1. Two slightly different faunas are found in the silts exposed at Timms Point: a typical cool-water fauna above and a somewhat warmer-water transitional fauna below.

2. Reworking of fossils from beds exposed at Second Street and not indigenous to Timms Point indicates that the section at the latter locality overlies everything except the cool-water zone of sands above the calcareous beds at Second Street.

3. The small percentage of extinct species, the presence of a cool-water fauna attributable to a glacial stage, and the very modern aspect of faunas underlying that section in the vicinity of San Pedro indicate that these beds are best considered Pleistocene instead of Pliocene.